Print ISSN: 0976-2876 Online ISSN: 2250-0138

Available online at: http://www.ijsr.in

INDIAN JOURNAL OF SCIENTIFIC RESEARCH

DOI:10.32606/IJSR.V16.I1.00007

Received: 20-05-2025 Accepted: 26-07-2025 Publication: 31-08-2025

Indian J.Sci.Res. 16 (1): 41-47, 2025 Original Research Article

EMPIRICAL INVESTIGATION OF INDIAN MEDICINAL PLANTS IN SONBHADRA REGION OF UTTAR PRADESH

ASHISH KUMAR SINGH[a1] AND DEEPMALA PATHAK[b]

[ab]Department of Botany, Mansarovar Global University, Sihor, Bhopal, M.P., India

ABSTRACT

Medicinal plants, particularly Indian herbs, have been used for 2,000 years in herbalism and are crucial for health maintenance and disease combat. The pharmaceutical industry is now focusing on plants, with 25% of prescription medications originating from tropical forests and 74% from traditional herbal remedies. Indian medicinal plants are essential to Ayurveda and treat chronic ailments like cancer. This study assessed medicinal plants in the Sonbhadra area of Uttar Pradesh, concentrating primarily on *Solanum nigrum* and *Andrographis Paniculata*. *Solanum nigrum*, known for its hepatoprotective properties, is often used in Ayurvedic and Siddha medicine to treat liver disorders, including jaundice and hepatitis. It is known for its anti-inflammatory and analgesic properties, rendering it beneficial in alleviating pain and swelling associated with joint disorders and dermatological conditions. Current research is exploring its potential as a source of innovative pharmacological agents, especially for liver protection, inflammation control, and cancer treatment. *Andrographis Paniculata*, often referred to as Kalmegh or King of Bitters, is a highly regarded medicinal plant in traditional medical systems such as Ayurveda, Traditional Chinese Medicine (TCM), and Siddha. Research indicates that air pollutants adversely impact the therapeutic characteristics of these two plants, necessitating governmental intervention to impose restrictions and control emissions from thermal power plants in order to mitigate the detrimental effects on these medicinal species and preserve biodiversity.

KEYWORD: Medicinal Plant, *Solanum nigrum, Andrographis Paniculata*, Pollution

Indian medicinal plants are fundamental to Ayurveda and its remedies, capable of addressing chronic ailments such as cancer. The use of plants for medicinal purposes is an old tradition and is a significant aspect of the healthcare system in India. Approximately 60% of the global population use medicines in India. In the West, the use of herbal medicines is increasing, with roughly 40% of the population reporting the usage of herbs to treat medical conditions in recent years (Dhawan and Rastogi, 2017). In China, traditional herbal remedies constitute 30–50% of overall medical usage, and the yearly worldwide market for herbal medicine exceeds 60 billion USD. Consequently, Western-trained clinicians must acknowledge the influence of traditional medicine on their patients (Hii and Shirkole, 2023). There is a growing interest among the general public, academia, and government in traditional remedies, driven by the rising incidence of adverse medication responses and the financial burden associated with contemporary medical practices. The primary regions for India's 45,000 species of medicinal plants are North-East India, the Eastern Himalayas, the Western Ghats, the Andaman and Nicobar Islands, and the Rarh area in West Bengal (Kumar and Jat, 2016). Traditional practitioners use around 6,000 remedies, despite only 3,000 being officially documented. India is renowned not just as the botanical garden of the globe but also for its plethora of medicinal herbs. India has a rich heritage of Ayurvedic medicine, a therapeutic system focused on the use of herbs and other botanical medicines (Akhtar and Kumar, 2019).

The medicinal flora of the Vindhya region in Eastern Uttar Pradesh, India, is inadequately documented due to insufficient systematic ethnomedicinal research. The Vindhya region of Uttar Pradesh includes the Mirzapur and Sonbhadra Districts, mostly distinguished by wooded landscapes (Dharm and Pramod, 2017). There is a scarcity of therapeutic product development and local expertise on medicinal plants. Traditional remedies are swiftly declining due to the migration of practitioners from rural to urban areas. The persistent reduction of medicinal plants in the studied region is due to both natural and anthropogenic factors, which erode the traditional knowledge associated with these plants (Singh, 2012). An ethnobotanical research was performed in the Vindhya region, namely in the Mirzapur and Sonbhadra Districts. This research mostly concentrated on the medicinal plants found in Sonbhadra District (Pandey *et al.*, 2021). In Sonbhadra District of Uttar Pradesh several plant species are gworn naturally which are used in herbal medicines such as *Acacia nilotica, Achyranthes aspera. Acorus calamus, Adhatodavasica, Aegle marmelos, Aloe vera, Andrographis Paniculata, Argemone Mexicana,*

[1]Corresponding author

Asparagus racemosus, Bautinia variegate, Boerhaaviadiffusa, Butea monosperma, Calotropis procera, Cassia fistula, Cassia tora, Chlorophytum tuberosum, Cinnamomum tamala, Clitoriaternatea, Cuscuta reflex, Cynodondactylon, Cyperus rotundus, Datura metal, Eclipitaprostrata, Emblica officinalis, Euphorbia hirta, Ficus glomerata, Ficus religiosa, Gloriosa superha, Glycyrrhiza glabra, Jatropha gossypifolia, Mentha arvensis, Mimosa pudica, Ocimum sanctum, Phyllanthus niruri, Piper Longum, Plantago ovata, Plumbago Zeylanica, Prosopis julifora, Rauwolfia serpentina, Ricinus communis, Saccharum spontaneum, Sapindusmukorossi, Saracaasoka, Solanum nigrum, Solanum Surattense, Tephorosia purpurea, Tinospora cordifolia, Tribulus terrestris, Vitex negundor-1 and Withaniasomnifera. The location of Sonbhadra District of Uttar Pradesh has been shown with the help of map in Figure 1.

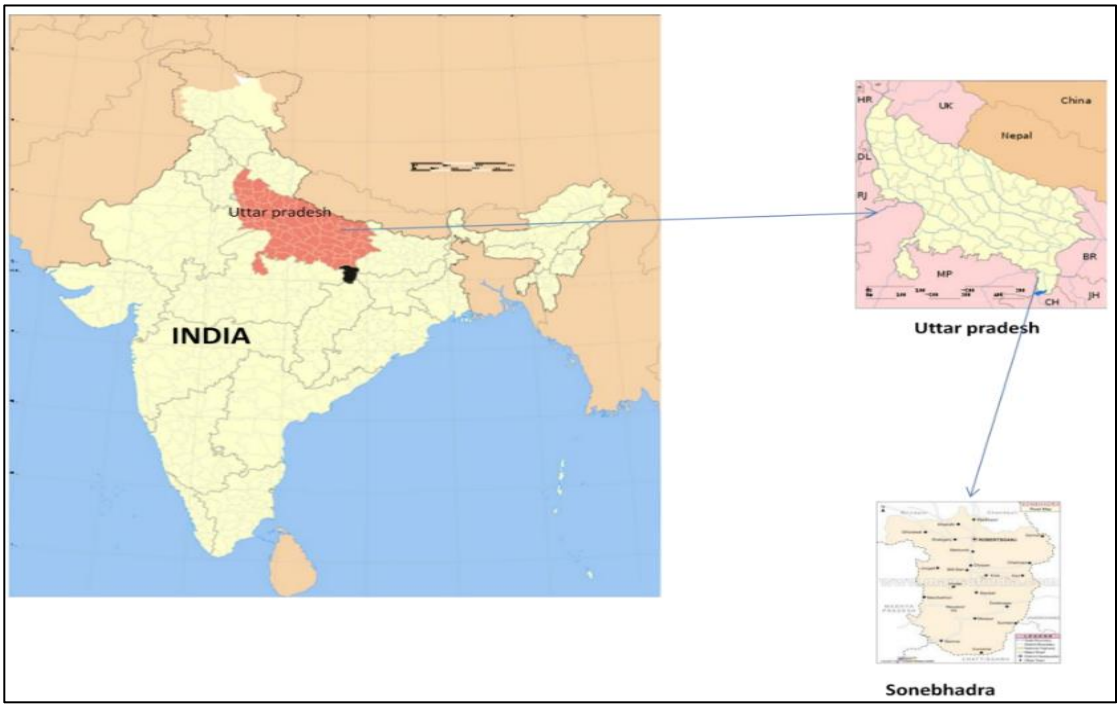

Figure 1: Sonbhadra District of Uttar Pradesh, India

Source:http://en.wikipedia.org/wiki/File:India_Uttar_Pradesh_locator_map.svg.http://wikiflex.wikispaces.com/file/view/Uttar_Pradesh.png/133903651/Uttar_Pradesh.png.http://www.mapsofindia.com/maps/uttarpradesh/roads/sonbhadra.htm

Since the Industrial Revolution, air pollution in India has significantly increased, particularly in industrial areas and urban centres. The concentration of contaminants near emission sources is determined by the emission rate and transport mechanisms (Hongfa, 1989; Kumar *et al.*, 2007). Thermal Power Plants (TPPs) promote national development but release significant quantities of particulate matter and gaseous pollutants, leading to a decline in air quality. The principal pollutants in the vicinity of thermal power plants are sulphur dioxide (SO_2) and fly ash, mostly generated by the combustion of fossil fuels. Changes in soil ionic composition and pH negatively affect cation exchange, hence influencing the absorption and distribution of mineral nutrients in medicinal plants. This study examines the impact of emissions from the Anapara Thermal Power Plant on the composition of the medicinal plants *Solanum nigrum* and *Andrographis Paniculata*. In this work, we mainly focused on the two medicinal plant species such as *Solanum nigrum* and Andrographis paniculate (Parveen *et al.*, 2007).

Solanum nigrum

Solanum nigrum, often known as Hound's Berry or popolo, is a member of the Solanaceae family. Black nightshade is a rather widespread plant found mostly in woodland regions and disturbed habitats. The flower has petals that transition from greenish to white, recurved with maturity, and are encircled by a conspicuous brilliant yellow margin. The fruits are tiny, oval-shaped black berries that grow in bunches. The mature black tiny fruits are edible, and the leaves are prepared and eaten. The green and black barriers, together with mature leaves, contain glycoalkaloids and are toxic if ingested. Their toxicity fluctuates, and they are the same strains that possess edible barriers when completely mature. Tigogenin extracted from root and stem Fatty oil extracted from seeds included palmitic, stearic, oleic, and linoleic acids, with linoleic acid (72%) being the predominant component. This plant has ethnomedicinal properties, serving as an antidote to opium toxicity and addressing ailments such as boils, fever, goitre, haemorrhoids, sores, sprains, stomachaches, swelling, oral ulcers, urinary issues, liver disorders, and skin illnesses (Buragohain, 2008; Singh and Singh, 2009). (Figure 1)

Figure 1: *Solanum nigrum*

Andrographis Paniculata

A. Paniculata, a member of the Acanthaceae family, is found in India. A paniculata is also referred to as Kirata, tikta, chryata, Great, and Kalmegh. It attains a height of 0.05-1.0 meter in marshy and shaded areas, with glabrous leaves and white blooms adorned with rose-purple spots. The stem is quadrangular, especially in the top section. The epidermis contains both glandular and non-glandular hairs, and the stomata are of the caryophyllaceous type. The ethnomedicinal applications of this plant include cholera, colic, diarrhoea, dysentery, fever, filariasis, malaria, gastrointestinal disorders, tonic, blood purification, and dermatological ailments. (Thirumalai *et al.*, 2012) (Figure 2)

Figure 2: *Andrographis Paniculata*

Recent Research have validated several traditional uses, indicating that *Andrographis Paniculata* may modulate the immune system, reduce inflammation, and combat various pathogenic diseases. Studies have shown its efficacy in managing chronic diseases such as hypertension, diabetes, and cancer, attributable to its antioxidant and anti-proliferative characteristics. Despite its many benefits, high doses or prolonged use should be approached with caution, since it may provoke unpleasant effects such as gastrointestinal discomfort or allergic reactions in some individuals. *Andrographis Paniculata* is a powerful medicinal plant with several therapeutic applications and is gaining global recognition for its use in natural and integrative medicine. Figure 2 illustrates the several ethnomedicinal plants found in the Sonbhadra area (Singh *et al.*, 2013).

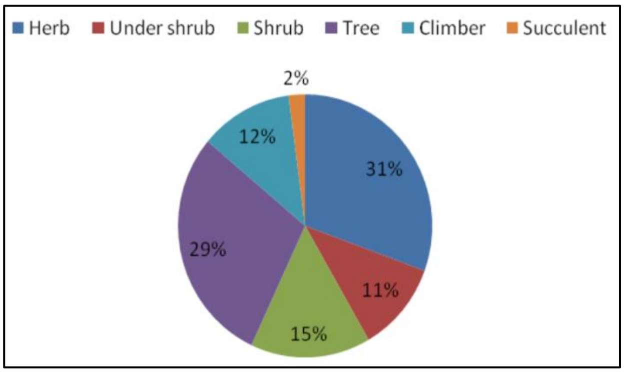

Figure 2: Ethnomedicinal plants of Sonbhadra District

THERMAL POWER PLANTS IN SONBHADRA DISTRICT AND THEIR IMPACT ON MEDICINAL PLANTS

Study Site

Sonbhadra is the second largest District in Uttar Pradesh, India. Sonbhadra is the only District in India that borders four states: Madhya Pradesh, Chhattisgarh, Jharkhand, and Bihar. In the esteemed television show Kaun Banega Crorepati, a question with a reward of 50 lakhs was presented based on the previously given fact. The District has an area of 6,788 km² and has a population of 1,862,559 as per the 2011 census, resulting in a population density of 270 people per km². It is situated in the far southeast of the state, bordered by Mirzapur District to the northwest, Chandauli District to the north, Kaimur and Rohtas Districts of Bihar to the northeast, Garhwa District of Jharkhand to the east, Koriya and Surguja Districts of Chhattisgarh to the south, and Singrauli District of Madhya Pradesh to the west. The District headquarters is located at Robertsganj. Sonbhadra District is an industrial region rich in resources like as bauxite, limestone, coal, and gold. Sonbhadra is designated as the Energy Capital of India because to the existence of several power units. Coal-based thermal power plants and coal mining activities have contributed to industrial pollution in this area. The ample coal supply from the mines, the abundant water availability in the vicinity, and the geography of the Singrauli region render it well suited for the development of super thermal power plants, now operational in the area. 1. Renusagar: 285 MW capacities, commissioned in 1966. 2. Shaktinagar: Capacity of 2000 MW established in 1982. 3. Anpara: Capacity of 5000 MW, currently operating at 3500 MW. 4. Vindhyachal: Capacity of 2000 MW, now generating just 250 MW, commissioned in 1989 (Rajan *et al.*, 2014).

The present study will be conducted in areas most affected by the Anapara Thermal Power Plant. The Anpara Power Plant is located next to the village of Anpara, across the Rihand reservoir in the Sonebhadra District of Uttar Pradesh. The distance from Rihand Dam via the Pipri-Singrauli road is around 34 miles, and it is nearly 200 km from Varanasi. Varanasi is accessible by air, rail, and road from other major cities. The research region is situated between Latitude 24°0'15" N and Longitude 82°40'9" E in the Sonbhadra District of Uttar Pradesh, India. The region's terrain is characterised by rolling hills, valleys, and alternating flats. The altitude varies from 225 to 450 meters above mean sea level. The NTPC Anapara industrial belt has emerged as one of the fastest-growing industrial centres in the nation. This region has eleven open cast mining blocks. Currently, nine units are operational, however one is out of service due to a recent incident (Dutt *et al.*, 2015).

Moreover, TPP emissions may pose a threat to flora and fauna. The detrimental consequences are documented as physiological and biochemical alterations, visible damage, and decreased vitality of plants. To evaluate the impact of air pollution on vegetation near emission sources, data on ambient air quality and existing environmental conditions in the region are required. The air quality data may function as the plant exposure dosage in environmental impact analysis studies (Shayganni *et al.*, 2016. Air analysis quantitatively determines the concentration of air pollutants, temporal trends, and geographical distribution. Numerous studies have shown both direct and indirect impacts of fly ash and SO_2 on medicinal plants, including stunted development, diminished quality, and alterations in the morphological, physiological, and biochemical processes of these plants (Prasad and Rao, 2016).

This Research examines the effects of air pollutants, including as SO_2, generated by the Anapara TPP in the Sonbhadra District of Uttar Pradesh, on some medicinal plants, notably *Solanum nigrum* and *Andrographis Paniculata*. This research investigates the effects of detrimental pollutants on several medicinal plants commonly used for medical treatment.

METHODOLOGY

This study employed a quantitative approach to gather research data.

Study Site

Figure 1 illustrates the geographical position of Sonbhadra District in Uttar Pradesh. This study primarily examines the two medicinal plant species, *Solanum nigrum* and *Andrographis Paniculata*, which are elaborated upon below:

Study Sample

Study performed on two medicinal plants namely *A. Paniculata and S. nigrum.* The Concentrations and Cumulative doses of SO_2, NO_2 pollutants which induced foliar injury in *A. Paniculata and S. nigrum.*

Sampling Method

An experimental sampling method was used, whereby NPP was measured by drying the plants in a hot air oven at 80ºC for 48 hours and assessing dry weight. Chlorophyll was extracted from a 0.5g fresh plant sample using 80% acetone. Extracts were filtered using muslin cloth and centrifuged at 3000g for 15 minutes. The supernatant was decanted and adjusted to 25 ml with 80% acetone. The capital density of the extract was determined at wavelengths of 645 and 663 nm using a spectrophotometer and a Lamb Spectrophotometer (U.S.A.). Chlorophyll content was determined using the formula provided by Maclachlan and Zalik.

$$\text{Chlorophyll a (mg/g fresh wt)} = \frac{12.3\, D\, 663 - 0.86 D615}{d \times 1000 \times w} \times V$$

$$\text{Chlorophyll b (mg/g fresh wt)} = \frac{19.3\, D\, 645 - 3.6 D645}{d \times 1000 \times w} \times V$$

Where V is the volume of chlorophyll solution in acetone, is the length (cm of path w is the fresh weight (g) of leaves.

The substantial impacts of location, year, and seasons were evaluated using analysis of variance (ANOVA), with necessary modifications used as needed. An F-test was conducted to assess the number of independent variables that account for variations in the dataset. SPSS is used for the analysis and management of quantitative data.

RESULTS

Exposure to elevated levels for short durations, as experienced during fumigation, may result in necrosis, the deterioration or demise of tissues. A necrotic pattern may develop on the leaves due to cellular death and degeneration. Leaf tissues undergo localised necrosis owing to acidity, resulting in a brown appearance. Leaf epinasty refers to the downward curving of a leaf resulting from accelerated development on the top surface. (Figure 3 to 8)

Chlorosis is the phenomenon characterised by the loss or reduction of chlorophyll, the green pigment in plants. A deficiency of chlorophyll often indicates that the plant is not receiving enough essential nutrients, resulting in a pale-green or yellow appearance.

$$Chl^{-a} + 2H \xrightarrow{\text{hydrogen ion}} Phaeophytin^{b} + mg^{++}$$

(bluish green colour)

$$Chl^{-b} + 2H^{+} \longrightarrow Phaeophytin^{-b} + mg^{++}$$

(colourless)

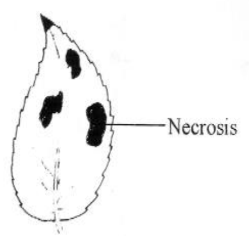

Figure 3: Leaf of *Solanum nigrum* showing Necrosis

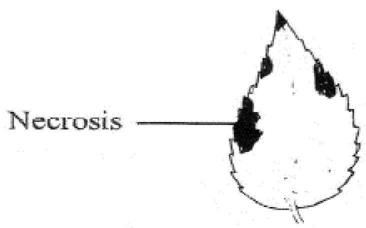

Figure 4: Leaf of *Andrographis Paniculata* showing Necrosis

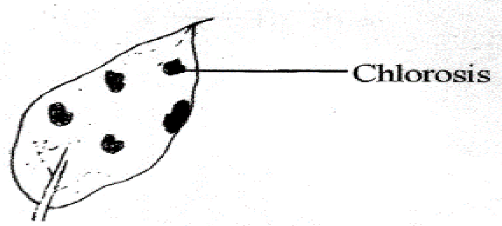

Figure 5: Leaf of *Solanum nigrum* showing chlorosis

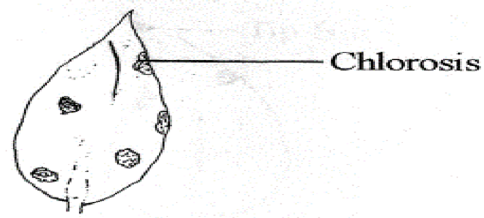

Figure 6: Leaf of *Andrographis Paniculata* showing chlorosis

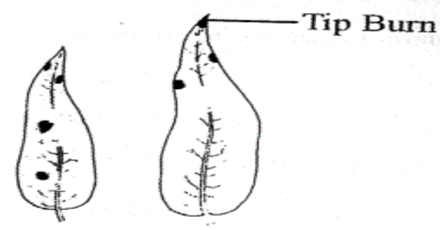

Figure 7: Leaf of *Solanum nigrum* showing tip burn

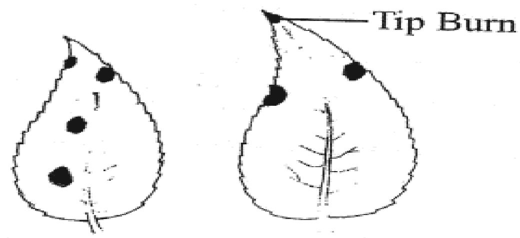

Figure 8: Leaf of *Andrographis Paniculata* showing tip burn

Crown foliage exhibits tips and internal and peripheral areas of necrotic brownish tissue. The microscopic analysis of this tissue demonstrates extensive plasmolysis, which leads to lesions at the leaf tip, finally resulting in senescence, death, and abscission of the leaf, i.e., necrosis of the leaf. The leaves are expanding while the apical buds often get desiccated. The bonds exhibit dieback, and the branches that carry them display significant defoliation due to dieback disease.

Table 1: Concentrations and Cumulative doses of SO_2, NO_2 pollutants which induced foliar injury in *A. Paniculata*

Pollutants	Concentration	Exposure duration (hrs/days)	Cumulative doses (Conc. x hrs. x days)
SO_2	0.25 ppm	2 x 15	7.5 ppm hour
SO_2	0.50 ppm	2 x 3	3.0 ppm hour
NO_2	0.25 ppm	2 x 15	6.5 ppm hour
NO_2	0.50 ppm	2 x 3	3.0 ppm hour

Table 2: Concentrations and Cumulative doses of SO_2, NO_2 pollutants which induced foliar injury in *S. nigrum*

Pollutants	Concentration	Exposure duration (hrs/days)	Cumulative doses (Conc. x hrs. x days)
SO_2	0.25 ppm	2 x 15	6.4 ppm hour
SO_2	0.50 ppm	2 x 3	2.0 ppm hour
NO_2	0.25 ppm	1 x 15	5.4 ppm hour
NO_2	0.50 ppm	1 x 3	1.5 ppm hour

Oxides of Nitrogen produced during the coal combustion in Thermal Power Plants Anpara receive tones of NO_2 per day because of industries and automobiles; NOx causes foliar lesion, chlorosis of leaves abscission of leaves and reduction in leaf area.”

CONCLUSION

Air pollution has been known to cause significant physiological changes in plants, with studies examining the effects of London Fog on chlorophyll and the effect of sulphur dioxide on photosynthesis. Coal-fired power plants are responsible for over 73% of the US's coal production, resulting in substantial amounts of solid waste and gaseous air pollution. Fly ash, a major component of combustion waste, is the predominant constituent of combustion waste. Sulphur dioxide (SO_2) and fly ash are the primary gaseous and particle contaminants near thermal power facilities, causing significant alterations in plant development. Fly ash particles obstruct gaseous and water vapour diffusion by clogging stomata, negatively impacting plant development. In addition, fly ash is directly deposited on soil surfaces, with conflicting accounts on its impact on plants when used as a soil additive. SO_2 emissions from coal-fired thermal power plants disrupt natural forests, terrestrial ecosystems, and agricultural crop productivity. The oxidation of atmospheric SO_2 occurs in various physical, chemical, and photochemical interactions, leading to reduced stomatal size, density, and increased trachoma size and number in plants growing in polluted areas. Short-term exposure to high concentrations of SO_2 results in acute injury symptoms, while chronic damage results from prolonged exposure to low concentrations. Experiments on *Solanum nigrum* and *Andrographis Paniculata* exposed to SO_2 and NO_2 air pollutants showed that sulphur dioxide (SO_2 & NO_2) hamper plant growth and suppress yield in various ways. Synergic responses are less than additive at higher pollutant concentrations.

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